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Agricultural Memorandum No. 636

Excess Winter Rainfall in the East of Scotland

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Excess rainfall is a significant factor in the leaching of nutrients and of lime from the soil, and is of importance in land drainage. It has been calculated for each of the twenty years 1954 to 1973 for 44 stations in the main agricultural areas of Scotland, using the method of M.A.F.F. Technical Bulletin No. 24.[1] The material has been divided into three regions. Data for 15 stations in the East of Scotland (plus Berwick-on-Tweed in Northumberland because of the relevance of its records to the south eastern part of Berwickshire) are given in this paper. The North of Scotland is covered by 17 stations in Agricultural Memorandum No. 635, and the West of Scotland by 11 stations in Agricultural Memorandum No. 637. The division of the material is on the basis of the areas of responsibility of the three Colleges of Agriculture in Scotland.

2. Meteorological records for the twenty-year period were analysed to give estimated soil moisture deficits at monthly intervals. These were the basic data used in the analysis. A few stations with shorter periods of record or non-standard periods were included to improve coverage. The calculation assumes that the first two inches (50 mm) of soil moisture are available for evaporation by the plant cover at the full potential rate, that the next two inches (50 mm) are available at half rate, and that a final one inch (25 mm) can be extracted at quarter rate, i.e. a limit to soil moisture deficit of 5 in. (125 mm). However, in any period with an excess of rainfall over evaporation requirement the soil will be moistened from the top, and the excess will be available for evaporation at the appropriate higher rate. Full details of this type of calculation are given in M.A.F.F. Technical Bulletin No. 16.[2]

3. We define 'Excess Winter Rainfall' as the excess of rainfall over evaporation between the date of return of the soil to field capacity and the end of March. There is however a wide variation in date of return to field capacity from year to year and from place to place. At the one extreme in a very dry year a deficit of soil moisture may remain throughout an entire winter, with zero excess winter rainfall. At the other extreme, in high rainfall areas of Scotland there may be several years in twenty when no soil moisture deficit develops. In the latter case the excess winter rainfall is assumed to commence in July. 'Excess Spring Rainfall' in the three months April to June is examined separately.

4. Excess Winter Rainfall

The mean values of excess winter rainfall for the 16 stations are given in Table 1 in order of annual rainfall (R) with which they are highly correlated. The relationship between EWR and R is given in millimetres by

$$EWR = 0.92\,R - 420 \qquad (1)$$

with correlation coefficient between EWR and R 0.963. The annual rainfall average for the period 1916-50 was selected for this comparison because it is widely available for the whole of Scotland. As would be expected the correlation with annual rainfall

average for 1954–73 is even higher, 0.993. It must be stressed that these correlations are between the long-term averages of annual and excess winter rainfall, not for individual years.

The excess winter rainfall mean values are seen to range from 20 to 25 per cent of annual rainfall in the coastal areas of Angus, East Fife, East Lothian and Berwick-on-Tweed to about 50 per cent at stations with annual rainfall in excess of 850 mm (i.e. hill stations at heights above 200 m in this part of Scotland).

The standard deviation of the yearly values from the mean are given, also the upper and lower quartiles and the extremes. In about one year in twenty in the low rainfall regions of East Scotland (coastal Angus, East Fife, East Lothian and south-east Berwickshire a deficit of soil moisture remains throughout the entire winter, giving zero excess winter rainfall.

The standard deviation (s.d.) of excess winter rainfall is given by

$$\text{s.d.} = 0.17\ \text{EWR} + 55 \qquad (2)$$

with correlation 0.88.

Estimates of excess winter rainfall and standard deviation for any other station can be derived from equations (1) and (2), given only the 1916–50 annual average rainfall. Quartiles and approximate extreme values can be estimated by interpolation in Table 1.

5. Excess Spring Rainfall

Mean values of excess spring rainfall (ESR) are given in Table 2, also the maximum values of ESR at each station and the number of years (N) in twenty in which ESR occurred. ESR is given with adequate accuracy by the expression.

$$\text{ESR} = 0.08\ R - 48 \qquad \text{Correlation } 0.92 \qquad (3)$$

6. Comments or suggestions regarding this paper would be welcomed by the author.

References

1. "The Significance of Winter Rainfall over Farmland in England and Wales", Technical Bulletin 24, Ministry of Agriculture, Fisheries and Food, 1971.

2. "Potential Transpiration", Technical Bulletin 16, Ministry of Agriculture, Fisheries and Food, 1967.

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15 November 1974

Table 1. Excess Winter Rainfall (EWR)

Station (a)	Height m	Period (b)	EWR Mean mm	s.d. mm (c)	Quartiles mm		Extremes mm		R mm (d)
Berwick-on-Tweed	21		155	75	100	225	0	260	590
Dunbar	23		115	80	70	175	0	260	595
Haddington	49	56–73	170	95	90	245	0	360	650
Arbroath	29		155	75	95	215	0	275	670
Leuchars	10		205	100	120	300	15	370	680
Montrose	5	34–53	215	90	145	285	60	390	685
Turnhouse	35		215	110	150	305	0	405	685
Mylnefield	30		255	95	175	335	15	365	715
Carnoustie	9	52–71	220	85	170	290	40	350	740
Kirkcaldy	32		275	110	180	355	40	460	755
Blairgowrie	70	61–73	280	75	215	345	115	370	760
Perth	23		320	115	215	405	60	530	780
Marchmont	152		305	120	210	395	20	490	780
Sourhope	221		435	140	305	555	105	640	880
Bush	184		375	130	275	465	85	585	905
Blyth Bridge	253	57–73	410	100	340	490	165	588	915

(a) Stations listed in order of R

(b) Period if differing from 1954–73

(c) Standard deviation of EWR

(d) Rainfall average 1916–50

Table 2. Excess Spring Rainfall (ESR)

Station (a)	Height m	R mm (b)	ESR Mean mm	ESR Max mm	N (c)	Grid ref
Berwick-on-Tweed	21	590	1	19	2	NU 0053
Dunbar	23	595	3	27	3	NT 6779
Haddington	49	650	4	35	(4)	NT 5174
Arbroath	29	670	5	71	3	NO 6541
Leuchars	10	680	8	74	5	NO 4721
Montrose	5	685	7	90	6	NO 7162
Turnhouse	35	685	8	54	8	NT 1674
Mylnefield	30	715	15	85	9	NO 3430
Carnoustie	9	740	10	80	7	NO 5624
Kirkcaldy	32	755	13	77	8	NT 2791
Blairgowrie	70	760	17	119	(11)	NO 1744
Perth	23	780	20	121	10	NO 1024
Marchmont	152	780	16	50	13	NT 7448
Sourhope	221	880	29	158	15	NT 8520
Bush	184	905	20	82	14	NT 2464
Blyth Bridge	253	915	23	61	(18)	NT 1446

(a) Stations listed in order of R

(b) Rainfall average 1916-50

(c) Number of years in 20 with an excess of spring rainfall.
The numbers given in brackets are from periods of record shorter than 20 years, but are scaled up to 20-year values.

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